

Autonomous Attitude Control Fault Protection for the Galileo Probe Mission and Jupiter Orbit Insertion*

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ABSTRACT

In July 1995, the Galileo spacecraft released an atmospheric entry probe on an impact trajectory with Jupiter. Both the Probe and the Orbiter spacecraft arrived at Jupiter on 11 December 'J, 1995, for a 75 minute rendezvous in which Jovian atmospheric data was relayed from the Probe instruments to the Orbiter as the Probe entered and descended into Jupiter's atmosphere. Following Probe Relay, the orbiter was spun up to 10.5 rpm and the main 400N engine was on for 19 minutes to slow down the spacecraft and allow it to be captured into orbit.

Galileo Mission guidelines dictated that the Probe data acquisition and successful Jupiter orbit Insertion (JOI) be guaranteed even in the presence of single point failures. This project requirement was particularly demanding in light of the fact that these time critical events occurred within the most severe radiation environment of the entire Jovian orbital tour.

During Relay, the attitude and articulation control subsystem (AACS) was responsible for controlling one of the two degrees of freedom of the Probe Relay. In preparation for JOI, AACS was responsible for executing the spin up maneuver and opening the main engine latch valves and pilot valve. Finally, AACS accelerometers were used for closed loop control of the spacecraft's delta velocity during JOI.

To provide the necessary robustness and single fault tolerance for 100% Relay and JOI required the development of new algorithms and autonomous fault protection logic within the AACS flight computer. To insure accurate pointing of the Probe Relay antenna, the existing attitude determination algorithms were modified and a completely new backup method for controlling the position of the Relay antenna based on sun sightings was designed and implemented. The spin up algorithm and associated fault protection was also added. Finally, the JOI burn termination logic was modified to avoid serious overburn scenarios resulting from single point failures.

This paper will describe in detail the AACS flight software and associated fault protection strategy that was required to execute the critical mission activities and provide single fault tolerance during Probe Relay and JOI. Problems encountered during development and test will be described as well as the solutions to those problems. The actual in-flight experience will be described and lessons learned will be presented.

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